Observations on the Habits of Ants, Bees, and Wasps.—Part VI. Ants.

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Ants.

Plant-hairs and Fur preventative against Ants climbing.

When I first began keeping ants, I surrounded the nests by moats of water. This acted well; but the water required continually renewing, especially, of course, in summer, just when the ants were most active. At length, however, in considering the habits of ants and their relations to flowers, another plan suggested itself to me. The hairs by which plants are clothed are of various forms, and fulfil various functions. One is, I believe, to prevent ants and other creeping insects from climbing up the plants so as to obtain access to the flowers, and thus rob them of their honey.

It occurred to me, therefore, that instead of water I might use fur arranged so that the hairs pointed downwards. This I have found to answer perfectly; and I mention it specially because the same arrangement may be found practically useful in hot climates. It is, of course, very possible that in hot countries the fur might be open to objections which do not occur in England; and, again, the tropical species might be able to climb up the fur; but at any rate the experiment would be worth trying.

Workers frequently fertile as well as Queens, but produce usually Males.

It is generally stated that among ants the queens only lay eggs. This, however, is not correct.

Denny* and Lespès† have shown that the workers also are capable of producing eggs; but the latter asserted that these eggs never come to maturity. Forel, however, has proved‡ that this is not the case, but that in some cases, at any rate, the eggs do produce young. Dewitz even maintains§ that the workers

* Ann. & Mag. Nat. Hist. 2nd ser. vol. i. p. 240.

† Ann. des Sci. Nat. 1863.

‡ Fourmis de la Suisse, p. 329.

§ Zeit. f. wiss. Zool. vol. xxviii. p. 536.

habitually lay eggs, and explains the difference which on this view exists between the workers of ants and those of bees, on the ground that (as he supposes) the majority of ants die in the autumn, so that the eggs laid by the queens alone would not be sufficient to stock the nest in the spring; while among bees the majority survive the winter, and consequently the eggs laid by the queen are sufficient to maintain the numbers of the community. In reply to this argument, it may be observed that among wasps the workers all perish in the autumn, while, on the contrary, among ants I have proved that, at least as regards many species, this is not the case. Moreover, although eggs are frequently laid by workers, this is not so often the case as Dewitz appears to suppose. Forel appears to have only observed it in one or two cases. In my nests the instances were more numerous; and, indeed, I should say that in most nests there were a few fertile workers.

Among bees and wasps also the workers are occasionally fertile; but, so far as our observations go, it is a curious fact that their eggs never produce females, either queens or workers, but always males. The four or five specimens bred by Forel from the eggs of workers were, moreover, all males.

It would therefore be interesting to know whether the same is the case generally among ants; and my nests have supplied me with some facts bearing on the question. Most of my nests contained queens; and in these it would be impossible, or at least very difficult, to distinguish and follow the comparatively few eggs laid by the workers. Some of my nests, however, contained no queen; and in them therefore all the eggs must have been laid by workers.

One of these was a nest of *Formica cinerea*, which I brought back from Castellamare in November 1875. At that time it contained no eggs or larvæ. In 1876 a few eggs were laid, of which fifteen came to maturity, and were, I believe, all males. Last year there were fourteen pupæ, of which twelve came to maturity and were all males.

Again, in a nest of *Lasius niger*, kept in captivity since June 1875, there were in 1876 about 100 young; and these were, as far as I could ascertain, all males. At any rate there were about 100 males, and I could not find a single young female. In 1877 there were again some pupæ; but none of them came to maturity. Last year fifteen have come to maturity; and fourteen

were males. The other I could not find; but I have no doubt, from the appeacance of the pupa, that it was also a male.

Another nest of *Lasius niger*, captured in November 1875, in 1878 brought only one young ant to maturity; and this was a male.

Again, in a nest of *Formica fusca* captured in 1875, though in 1876 and 1877 eggs were laid and a few arrived at the pupa-state, none came to maturity. They were all, however, either males or queens, and, I have little doubt, were males. This year one came to maturity, and it was a male.

Another nest of *F. fusca*, captured in 1876, did not bring up any young in 1877. This year three larvæ came to maturity; and they all proved to be males. A nest of *F. fusca*, captured in 1877, in 1878 brought only one young one to maturity. This was a male.

In these species, then, as far as the evidence goes, it would seem that, as in bees, the workers can produce males only. On the other hand, I ought to add that in a nest of *Lasius flavus* captured in 1876 a number of workers were produced this year. In this species the larvæ live through the winter; but I can hardly believe they take two years in coming to maturity. Nor do I think the ants had access to any other larvæ; still I would not attach too much importance to this isolated case. In the case of bees we know that the queen is brought up on different food from the workers. Whether this is the case among ants, we have no knowledge. I am, however, disposed to believe it; because while hundreds, I might say thousands, of workers have been bred in my nests, and a large number of males, not a single queen has been produced in any one of them.

As to the Relations of Ants and their Domestics.

M. Lespès has given a short but interesting account of some experiments made by him on the relations existing between ants and their domestic animals, from which it might be inferred that even within the limits of a single species some communities are more advanced than others. He found that specimens of the curious blind beetle *Claviger*, which always occurs with ants, when transferred from a nest of *Lasius niger* to another which kept none of these domestic beetles, were invariably attacked and eaten. From this he infers that the intelligence necessary to keep Clavigers is not coextensive with the species, but belongs

only to certain communities and races, which, so to say, are more advanced in civilization than the rest of the species.

With reference to the statements of Lespès, I have more than once transferred specimens of *Platyarthrus* from one nest to another, and always found them received amicably. I also transferred specimens from a nest of *Lasius flavus* to one of *Formica fusca* with the same result. I even brought from the South of France some specimens of a different species, I believe *Typhlopone*, and put them in a nest of *Formica fusca*, where they are still living, and have brought up more than one brood of young. These species, however, occur in most ants' nests, while Clavigers are only found in some.

Longevity of Ants.

In my previous paper I have called attention to the longevity of ants, which has proved to be much greater than I had expected. One of my nests of *Formica fusca* was brought from the woods in December 1874. It then contained two queens, both of which are (May 1879) still alive. I have little doubt that some of the workers now in the nest were among those originally captured, the mortality after the first few weeks having been but small. This, however, I cannot prove.

In the following nests, however—viz. another nest of *Formica fusca*, which I brought in on the 6th June, 1875, one of *Lasius niger* on the 25th July, 1875, of *Formica sanguinea* (kindly sent me by M. Forel from Munich) on the 12th September, 1875, and of *F. cinerea* on the 29th November, 1875—there were no queens; and, as already mentioned, no workers have been produced. Those now living are therefore the original ones; and they must therefore now be between three and four years old.

In fact, though I lose many ants from accidents, especially in summer, in winter there are very few deaths.

On the mode of recognition of Friends.

It is clear, from the experiments recorded in the present and in my former papers, that the ants recognize their fellows in the same nest; but it is very difficult to understand how this can be effected. The nests vary very much in size; but in some species 100,000 individuals may be by no means an unusual number, and in some instances even this is largely exceeded. Now it seems almost incredible that in such cases every ant knows

every other one by sight. Neither does it seem possible that all the ants in each case should be characterized from those of other nests by any physical peculiarity.

It has been suggested that ants may recognize one another by scent. This, however, I think, cannot be the explanation. For instance, when intoxicated, ants were recognized; surely the whiskey must have obliterated any natural odour. Again, I have kept ants for forty-eight hours in an atmosphere strongly scented with musk; but when returned to the nest they were recognized without the least doubt or hesitation.

It has been suggested in the case of bees that each nest might have some sign or password.

The whole subject is full of difficulty. It occurred to me, however, that experiments with pupæ might throw some light on the subject. Although the ants of every nest, say of *Formica fusca*, are deadly enemies, still if larvæ or pupæ from one nest are transferred to another, they are kindly received, and tended with apparently as much care as if they really belonged to the nest. In ant-warfare, though sex is no protection, the young are spared, at least when they belong to the same species. Moreover, though the habits and disposition of ants are greatly changed if they are taken away from their nest and kept in solitary confinement, or only with a few friends, still, under such circumstances, they will carefully tend any young which may be confided to them. Now if the recognition were effected by means of some signal or password, then, as it can hardly be supposed that the larvæ or pupæ would be sufficiently intelligent to appreciate, still less to remember it, the pupæ which were intrusted to ants from another nest would have the password, if any, of that nest; and not of the one from which they had been taken. Hence, if the recognition were effected by some password or sign with the antennæ, they would be amicably received in the nest from which their nurses had been taken, but not in their own.

In the first place, therefore, I put, on the 2nd of September 1877, some pupæ from one of my nests of *Formica fusca* with a couple of ants from the same nest. On the 27th I put two ants, which in the meantime had emerged from one of these pupæ, into the nest at 8.30 A.M., marking them with paint as usual. At 9 they seemed quite at home; at 9.30, ditto; at 10, ditto; and they were nearly cleaned. After that I could not distinguish them.

On the 29th another ant came out of the pupa-state; and on

the 1st October at 7.45 I put her into the nest. She seemed quite at home, and the others soon began to clean her. We watched her from time to time, and she was not attacked; but, the colour being removed, we could not recognize her after 9.30.

On the 14th July last year (1878) I put into a small glass some pupæ from another nest of *Formica fusca* with two friends.

On the 11th August I put four of the young ants which had emerged from these pupæ into the nest. After the interval of an hour, I looked for them in vain. The door of the nest was closed with cotton-wool; so that they could not have come out; and if any were being attacked, I think we must have seen it. I believe, therefore, that in the meantime they had been cleaned. Still, as we did not actually watch them, I was not satisfied. I put in, therefore, two more at 5 P.M. At 5.30 they were all right; at 5.45, ditto, but one was almost cleaned. At 6 one was all right; the other was no longer recognizable, having been quite cleaned. At 6.30 also one was quite at home; the other could not be distinguished. At 7 both had been completely cleaned.

The following day I marked another, and put her in at 6 A.M. At 6.15 she was all right among the others, and also at 6.30, 7, 7.30, 8, and 9.30, after which I could no longer distinguish her.

Again, on the following day I put in another at 6.45 A.M. At 7 she was quite at home, and also at 7.15, 7.30, 8, and to 9.30, after which I did not watch her.

To test the mode in which the ants of this nest would behave to a stranger, I then, though feeling no doubt as to the result, introduced one. The difference was very striking. The stranger was a powerful ant; still she was evidently uncomfortable, started away from every ant she met, and ran nervously about, trying to get out of the nest. She was, however, soon attacked.

Again, on the 1st October some pupæ of *Lasius niger* were placed in a glass with five ants from the same nest.

On the 8th December I took three of the ants which had emerged from these pupæ, and at midday put them back into their old nest, having marked them by nicking the hind leg. Of course, under these circumstances we would not watch the ants. I examined the nest, however, every half hour very carefully, and am satisfied that there was no fighting. The next morning there was no dead ant; nor was there a death in the nest for more than a fortnight.

December 21. Marked three more in the same manner, and

put them in at 11.15 A.M. Looked at the usual intervals, but saw no fighting. The next morning there was no dead one outside the nest; but I subsequently found one of these ants outside, and nearly dead. I am, however, disposed to think that I had accidentally injured this ant.

Dec. 23. Painted three, and put them in at 10 A.M. At 11 they were all right, 12 do., 1 do., 2 do., 3 do., 4 do., 5 do. At 3 I put in three strangers for comparison: two of them were soon attacked; the other hid herself in a corner. The next morning I found two ants outside the nest; and they were two of the strangers. On the 31st I found the third stranger dead outside the nest. Found no other dead ant for some days.

Dec. 29. Painted three more of the ants from the pupæ separated on the 1st Oct., and put them in at 10.30 A.M. At 11 they were all right, 12 do., 1 do., 2 do. During the afternoon they were once or twice attacked for a minute or two, but let go again almost directly. The next morning I found one dead ant, but had no reason to suppose that she was one of the above three. The following morning there was again only one dead ant outside the nest; she was the third of the strangers put in on the 23rd as mentioned above. Up to the 23rd Jan. found no other dead one.

Jan. 3, 1879. Painted three more and put them in at 11.30 A.M. At 12 two were all right: we could not see the third; but no ant was being attacked. 12 do. 1, all three are all right; 2, do.; 5 do.

As already mentioned, for some days there was no dead ant brought out of the nest.

Jan. 5. Painted three more and put them in at 11.30 A.M. At 12 two were all right among the others; I could not find the third; but no ant was being attacked. 12.30 do., 1 do., 2 do., 4 do.

Jan. 6. Found two of them all right among the others. There was no dead ant.

Jan. 13. Painted three more and put them in at 12.30. At 1 they were all right. 2 do. 4, two were all right; I could not see the third, but she was not being attacked. The next morning, when I looked at the nest, one was being just carried, not dragged, out. The ant carried her about 6 inches and then put her down, apparently quite unhurt. She soon returned into the nest and seemed to be quite amicably received by the rest. Another one of the three also seemed quite at home. The third

I could not see; but up to the 23rd Jan. no dead one was brought out of the nest.

Jan. 19. Marked the last three of these ants and put them into the nest at 9.30 A.M. They were watched continuously up to 1. At that time two of them had been almost completely cleaned. One was attacked for about a minute soon after 11, and another a little later; but with these exceptions they were quite amicably received, and seemed entirely at home among the other ants.

Thus every one of these 32 ants was amicably received.

These experiments, then, seem to prove that ants removed from a nest in the condition of pupæ, but tended by friends, if reintroduced into the parent nest, are recognized and treated as friends. Nevertheless the recognition does not seem to have been complete. In several cases the ants were certainly attacked, though only by one or two ants, not savagely, and only for a short time. It seemed as if, though recognized as friends by the great majority, some few, more ignorant, or more suspicious, than the rest, had doubts on the subject, which however, in some manner still mysterious, were ere long removed. The case in which one of these marked ants was carried out of the nest, may perhaps be explained by her having been supposed to be ill, in which case, if the malady is considered to be fatal, ants are generally brought out of the nest.

It now remained to test the result when the pupæ were confided to the care of ants belonging to a different nest, though, of course, the same species.

I therefore took a number of pupæ out of some of my nests of *Formica fusca* and put them in small glasses, with ants from another nest of the same species. Now, as already mentioned, if the recognition were effected by means of some signal or password, then, as we can hardly suppose that the larvæ or pupæ would be sufficiently intelligent to appreciate, still less to remember it, the pupæ which were intrusted to ants from another nest, would have the password, if any, of that nest and not of the one from which they had been taken. Hence, if the recognition were effected by some password or sign with the antennæ, they would be amicably received in the nest from which their nurses had been taken, but not in their own.

I will indicate the nests by the numbers in my note-book.

On the 26th August last year, I put some pupæ of *Formica fusca*

from one of my nests (No. 36) with two workers from another nest of the same species. Two emerged from the chrysalis-state on the 30th; and on the 2nd September I put them, marked as usual, into their old nest (No. 36) at 9.30 A.M. At9.45 they seemed quite at home, and had already been nearly cleaned. At 10·15 the same was the case, and they were scarcely distinguishable. After that I could no longer make them out; but we watched the nest closely, and I think I can undertake to say that if they had been attacked we must have seen it.

Another one of the same batch emerged on the 18th August, but was rather crippled in doing so. On the 21st I put her into the nest (No. 36). This ant was at once attacked, dragged out of the nest, and dropped into the surrounding moat of water.

Again, on the 14th July last year (1878) I put some pupæ of *Formica fusca* from No. 36 into a glass with three ants of the same species from nest No. 60.

On the 22nd I put an ant which had emerged from one of these pupæ into her old nest (No. 36) at 9.30 A.M. She was at once attacked. 10, she is being dragged about. 10.30 do.

Aug. 8. Put another ant which had emerged from one of these pupæ into her old nest (No. 36) at 7.45 A.M. At 8 she seemed quite at home among the others. 8.15 do., 8.30 do., 9 do. 9.30 do.

Aug. 9. Put two other young ants of this batch into their old nest (No. 36) at 7 A.M. At 7.30 they were all right. At 7.30 one of them was being dragged by a leg, but only, I think, to bring her under shelter, and was then let go. Young ants of this species, when the nest is disturbed, are sometimes dragged to a place of safety in this way. At 8.30 they were all right and nearly cleaned. After this I could not distinguish them; but if they had been attacked, we must have seen it.

Aug. 11. Put in another one as before at 8.30 A.M. At 8·45 she was all right. At 9 she was dragged by a leg, like the last, but not for long; and at 9.30 she was quite comfortable amongst the others. 10 do., 10.45 do., 12 do., 5 do.

Aug. 24. Put in the last two ants of this lot as before at 9.15 A.M. At 9.30 they were all right. 9.45 do. At 10 they were almost cleaned. At 10.30 I could only distinguish one; and she had only a speck of colour left. She appeared quite at home; and though I could no longer distinguish the other, I must have seen it if she had been attacked.

Thus, then, out of seven ants of this batch put back into their

old nest, six were amicably received. On the other hand, I put one into nest No. 60, from which the three nurses were taken. She was introduced into the nest at 8.15 A.M., and was at once attacked. 8.45, she is being dragged about. 9, do.; 9.15, do.; 9.30, do. Evidently therefore she was not treated as a friend.

Again, on the 14th July last year (1878) put some pupæ of *Formica fusca* from nest No. 60 with three ants from nest No. 36.

On the 5th August at 4 P.M. I put an ant which had emerged from one of these pupæ, into her old nest (No. 60). At 5.15 she seemed all right. They were already cleaning her; and by 4.30 she was no longer distinguishable. We watched the nest, however, carefully for some time; and I feel sure she was not attacked.

Aug. 6. Put another of this batch into nest No. 60 at 7.15 A.M. At 7.30 she is not attacked. At 8, one of the ants was carefully cleaning her. At 8.15 she was quite at home among the others. At 8.30 do., she was nearly cleaned. 9.30 do.

Aug. 8. Put in another as before at 7.45. At 8 she is all right. 8.30 do., 9.30 do., 9.45 do.

Aug. 9. Put in another as before at 7 A.M. At 7.30 she is quite at home among the others, and already nearly cleaned. At 8 I could no longer distinguish her; but certainly no ant was being attacked. 9 do.

Aug. 11. Put in another as before at 8 A.M. At 8.15 she is quite at home. 8.30 do., 9 do., 9.30 do., 10 do., 12.30 do.

Aug. 13. Lastly, I put in the remaining young ant as before at 7 A.M. At 7.15 she was all right. At 7.30 do. and nearly cleaned. At 8 I could no longer distinguish her; but no ant was being attacked.

Thus, then, as in the preceding experiment, these six ants when reintroduced into the nest from which they had been taken as pupæ, were received as friends. On the other hand, on the 5th August I put a young ant of the same batch into nest No. 36, from which the three nurses had been taken. She was introduced at 11 and was at once attacked. At 11.30 she was being dragged about, and shortly after was put to death. I then introduced a second; but she was at once attacked like the first.

Aug. 22. I put some pupæ of *Formica fusca* from nest No. 64 under the charge of three ants from No. 60. By the 7th September several young ones had emerged. I put two of them into nest No. 64 at 8.15 A.M. They were amicably received, as in the pre-

ceding experiments, and the ants began to clean them. At 8.30 they were all right. 8.45 do. At 9 they had been completely cleaned so that I could not distinguish them; but there was no fighting going on in the nest.

On the same day, at 9.45 A.M. I put into nest 64 two more as before. At 10 they were both quite at home among the other ants. 10.15 do., 10.30 do., 11 do., 12 do., 1 do. I then put in a stranger; and she was at once fiercely attacked.

Sept. 8. Put in two more of the ants which had emerged from the pupæ, as before, at 9.30 A.M. At 9.45 they were all right. 10 do., 10.30 do., 11 do., 11.30 do., 12 do., 1 do.

On the other hand, on September 14, I put one of these ants in the same manner into nest No. 60 at 6.30 A.M. She was at once attacked. At 6.45 she was being dragged about by an antenna. 7 do. At 7.30 she was by herself in one corner. At 8.30 she was again being dragged about. 9.30 do. The difference, therefore was unmistakable.

Lastly, on July 29 I put some pupæ of *Formica fusca* from out of doors under the charge of three ants from nest No. 36.

Aug. 3. Several had come out, and I put two of them into the nest of their nurses (No. 36) at 2 P.M. Both were at once attacked. At 2.45 they were being dragged about. 3 do. 3.30 one was being dragged about. 4, both were being attacked. Eventually one was turned out of the nest. The other I lost sight of.

Aug. 4. Put two more of this batch into nest No. 36. at 12.30. One was at once attacked. 1, one is being dragged about by an antenna. 2.30, both are being attacked. At 2.45 one was dragged out of the nest.

I then put back one of the old ones; as might have been expected, she was received quite amicably.

I then tried the same experiment with another species, *Lasius niger*. I took some pupæ from two of my nests, which I knew not to be on friendly terms, and which I will call 1 and 2, and confided each batch to three or four ants taken from the other nest. When they had come to maturity I introduced them into the nests as before.

They were taken from their nest on the 20th Sept.; and the results were as follows.

Pupæ from nest 1 confided to ants from nest 2.

Sept. 20. Put one of the young ones into nest 2 at 7.15 A.M.

Several at once threatened her. At 7.25 one of the ants seized her by an antenna, and began dragging her about. 7.30, she was still being dragged about. 8, do. 8.15, she is now being dragged about by three ants. 8.30, she is still attacked. 9, do. At 9.15 she was dragged out of the nest.

Sept. 23. Put two of the young ants into nest 1 at 9.15 A.M. One was at once attacked, and the other a few minutes afterwards. 9.45, both are attacked. 10, do. One is now dead and hanging on to a leg of assailant. 10.15, do. 10.45, both are still being dragged about.

At 11 A.M. I put into nest 2 three more very young ones. At 11.10 one was attacked. At 11.20 all three were being viciously attacked, and yet one was nearly cleaned. At 12 one was being attacked, one was alone in a corner, the other we could not find. At 12.10 one was dragged out of the nest and then abandoned, on which, to my surprise, she ran into the nest again, which no old ant would have done. She was at once again seized by an antenna. At 12.30 she was still being dragged about; the second was being cleaned. In this instance, therefore, I think two out of the three were eventually accepted as inmates of the nest.

Sept. 25. Put two of the young ones into nest 1 at 2.30 P.M. At 2.45 one was attacked, but not viciously. 3 do., 3.15 do. No notice was taken of the other, though several ants came up and examined her. 3.30, the first is not attacked, the second is almost cleaned. 4, the first has been again attacked, but not viciously, and moreover has been partly cleaned. The second is evidently received as a friend, and is almost cleaned. 4.30, they are both comfortably among the others and are almost clean. At 5 I could no longer distinguish them.

I now pass to the other batch, namely, pupæ from nest 2 with ants from nest 1.

Sept. 25. Put three of the young ants into nest 1 at 9.30 A.M. At 9.45 two were attacked, the third was by herself. 10 do. At 10.15 one made her escape from the nest. At 10.20 the third was attacked. At 10.30 one of them was dragged out of the nest, and then abandoned. At 10·50 the third also was dragged out of the nest.

I then put two of these ants and a third young one into nest 2. At 11.15 A.M. they seemed quite happy; but at 11.30 two were being dragged about; the third, who was very young, was, on the contrary, being carefully cleaned. At 12 this last one was undis-

tinguishable; of the other two, one was being attacked, the second was taken no notice of, though several ants came up to her. At 12.5 the first was dragged out of the nest and then abandoned; the second was being carefully cleaned. This went on till 12.20, when the paint was entirely removed.

Sept. 27. I put in three more of these young ants into nest 1, at 7.45 A.M. At 8 o'clock they seemed quite at home among the other ants. A few minutes after, one was being held by a leg; the other two seemed quite at home. At 8.30 one was almost cleaned, one I could not see. At 9 two of them were quite at home, but I could not see the third. At 9.30 they were both all but cleaned; and after that we were no longer able to distinguish them.

Thinking the results might be different if the ants were allowed to become older before being returned into their nests, I made no further observations with these ants for two months. I then took two of the ants which had emerged from the pupæ separated on the 20th of September, and which had been brought up by ants from nest 2, and on the 22nd of November I put them back at 12 in their old nest (that is to say, in nest 1), having marked them as usual, with paint. They showed no signs of fear, but ran about among the other ants with every appearance of being quite at home. At 12.15 do. At 12.30 one was being cleaned. At 12.45 both were being cleaned; and by 1 o'clock they could scarcely be distinguished from the other ants. There had not been the slightest symptom of hostility. After this hour we could no longer identify them; but the nest was carefully watched throughout the afternoon, and I think I can undertake to say that they were not attacked. When we left off watching, the nest was enclosed in a box. The next morning I examined it carefully to see if there were any dead bodies. This was not the case; and I am satisfied, therefore, that neither of these two ants was killed. To test these ants, I then, on the 24th of November, at 8.30 A.M., put into the nest two ants from nest 2. At 8.40 one was attacked; the other had hid herself away in a corner. At 9.15 both of the ants were being dragged about. At 9.35 one was dragged out of the nest and then released, and the other a few minutes afterwards. After watching them for some time to see that they remained outside, I restored them to their own nest. The contrast, therefore, was very marked.

Again, on Nov. 25, I took two ants which had emerged from

pupæ belonging to nest 2, removed on the 20th September, and brought up by ants from nest 1, and put them back into their old nest at 2 P.M. They were watched continuously until 4 P.M., but were not attacked, nor even threatened. The following morning one of them was quite well, the other one had probably been cleaned. We could not distinguish her; but if she had been killed, we must have found her dead body. I then at 10 A.M. put in two more. At 10.30 one of them was attacked for a moment, but only for a moment. With this exception neither of them was attacked until 2 o'clock, when one of them was again seized and dragged about for a minute or two, but then released again. We continued watching them till half-past 4, when they seemed quite at home amongst the others. On the other hand a stranger, put in as a test at 12, was at once attacked. It was curious, however, that although she was undoubtedly attacked, yet at the very same time another ant began to clean her.

The next morning we found one ant lying dead in the box outside the nest; and this turned out to be the stranger of yesterday. She had been almost cleaned; but there were one or two infinitesimal particles of paint still remaining, so that there could be no doubt of her identity.

The next day, Nov. 27, I put in three more of the ants derived from these pupæ at 10 A.M. At 10.30 they were all right, running about amongst the others. At 11 o'clock the same was the case; but whilst I was looking again shortly afterwards, one of them was seized by an antenna and dragged a little way, but released again in less than a minute. Shortly afterwards one of the others was also seized, but let go again almost immediately. At 1 o'clock they were all right, and also at 2. They had, however, in the meantime been more than once threatened, and even momentarily seized, though they were never dragged about as strangers would have been. At 3 o'clock I found one of them dead; but I think I must have accidentally injured her, and I do not believe that she was killed by the other ants, though I cannot speak quite positively about it. The other two were all right, and had been partly cleaned. At 6 one of them was running about comfortably amongst the rest; the other I could not distinguish; but certainly no ant was being attacked.

Nov. 28. I put in the last two ants from the above-mentioned batch of pupæ at noon. Like the preceding, these ants were occasionally threatened, and even sometimes attacked

for a moment or two; but the other ants soon seemed to find out their mistake, and on the whole they were certainly treated as friends, the attacks never lasting more than a few moments. One of them was watched at intervals of half an hour until 5 P.M.; the other we could not distinguish after 3, the paint having been removed; but we should certainly have observed it had she been attacked.

On the whole, then, all the 32 ants belonging to *Formica fusca* and *Lasius niger*, removed from their nest as pupæ, attended by friends and restored to their own nest, were amicably received.

What is still more remarkable, of 22 ants belonging to *F. fusca*, removed as pupæ, attended by strangers, and returned to their own nest, 20 were amicably received. As regards one I am doubtful; the last was crippled in coming out of the pupa-case; and to this perhaps her unfriendly reception may have been due.

Of the same number of *Lasius niger* developed in the same manner from pupæ tended by strangers belonging to the same species, and then returned into their own nest, 19 were amicably received, three were attacked, and about two I feel doubtful.

On the other hand, 15 specimens belonging to the same two species, removed as pupæ, tended by strangers belonging to the same species, and then put into the strangers' nest, were all attacked.

The results may be tabulated as follows:—

	Pupæ brought up by friends and replaced in their own nest.	Pupæ brought up by strangers. Put in own nest.	Pupæ brought up by strangers. Put in strangers' nest.
Attacked.....	0	7*	15
Received amicably..	32	37	0

I propose next season to make some more experiments of this nature; but even the above results seem to me very interesting. The differences cannot be referred to any difference of temperament in different nests. For instance, any idea that the specimens of *Formica fusca* experimented with in August and September, and amicably received, were so on account of the peaceable character of the nests, is disposed of by the facts. Thus specimens of *F. fusca* experimented with in August and September last were taken principally from two nests, numbered respectively 36 and 60. Now, while nest 36, in most cases, amicably received ants bred from its own pupæ but tended by ants from 60, it showed itself fatally hostile to ants from pupæ

* About three of these I do not feel sure.

b orn in nest 60, even when these had been tended by ants from nest 36. Nest 60, again, behaved in a similar manner, as a general rule, amicably receiving its own young, even when tended by ants from 36; and refusing to receive ants born in nest 36, even when tended by specimens from 60.

These experiments seem to indicate that ants of the same nest do not recognize one another by any password. On the other hand, if ants are removed from a nest in the pupa-state, tended by strangers, and then restored, some at least of their relatives are certainly puzzled, and in many cases doubt their claim to consanguinity. I say some, because while strangers under the circumstances would have been immediately attacked, these ants were in every case amicably received by the majority of the colony, and it was sometimes several hours before they came across one who did not recognize them.

Suggestions as to the Relation &c. of second "Knot" and Sting.

I have elsewhere suggested* that the existence of a second "knot" in the Myrmicidæ stands perhaps in relation with their possession of a sting. The late Fred. Smith indeed, describes *Œcophylla*, which has only one knot, as having a sting; and I have the above-cited memoir admitted that this would be a difficulty, though not, I think, a conclusive argument against the suggestion. Forel† has since pointed out that the sting of *Œcophylla* is rudimentary. He rejects my view, however, on the ground that some ants which have two knots have only a rudimentary sting, such as *Pheidole*; while some of the Poneridæ have a well developed sting and yet only one knot.

In does not, however, seem to me that these cases are conclusive. The stings of ants are obviously homologous with those of Bees and other Hymenoptera. The sting may therefore be said to be more ancient than the ant; and as we may also assume that the ancestors of ants at one time had an abdomen of the more usual type, *i. e.* without a knot, the existence of ants with a sting and only one knot, so far from being inexplicable, is just what might have been expected. They represent in this respect an archaic phase through which the ancestors of *Myrmica* must have passed. The existence of a second knot, giving

* Monthly Micros. Journ. Sept. 1877.

† Zeit. f. wiss. Zool. 1878, vol. xxx. p. 30.

greater mobility to the sting, might have been an advantage, and thus gradually produced in certain cases, without necessarily being developed in others, in which, perhaps, some other advantage was enjoyed.

The so-called stingless ants, as Forel and Dewitz* have clearly shown, possess in reality a rudimentary sting; and their ancestors obviously had a more developed one. Such cases, therefore, as *Pheidole* and *Atta*, to which M. Forel refers, represent cases in which, perhaps with reference to the powerful development of the mandibles, the sting has fallen partly into disuse, and consequently has diminished in size. On the other hand, the second knot having once been formed, has retained its existence. It will be observed also that the "knot" in the Formicidæ, where it is single, is much more elevated than in the Myrmicidæ where there are two knots, and consequently two sets of muscles moving the abdomen. Thus, while the Myrmicidæ have two sets of muscles acting on the abdomen, and the Formicidæ only one, the difference is to a certain extent neutralized by the fact that the muscles in the latter family are longer than in the Myrmicidæ. This accounts I think, for the elevation of the knot or scale in *Formica* and the allied genera.

As to Sounds emitted by Ants.

In 'Nature' for December is a letter from Mr. T. S. Tait, who, writing from Baroda, says that by means of the microphone "we have been able to hear the roar of a black ant when attacked by its companion." It is unfortunate that Mr. Tait does not mention the species, because some of the Mutillidæ make a sound which is audible even to the naked ear. Moreover the expression "attacked by its companion" is curious, and does not harmonize with the usual habits of ants. Still I am quite disposed to believe that ants do produce sounds.

In the previous paper I have mentioned that I was never able to satisfy myself that my ants heard any sounds which I could produce. On the other hand, I have tried unsuccessfully various experiments, in order to ascertain whether the ants themselves produced any sounds for the purpose of conveying signs or ideas. Prof. Tyndall was good enough to arrange for me one of his sensitive flames; but I could not perceive that it responded in any

* Zeit. f. wiss. Zool. vol. xxviii.

way to my ants. The experiment was not, however, very satisfactory, as I was not able to try the flame with a very active nest. Prof. Bell most kindly set up for me an extremely sensitive microphone: it was attached to the underside of one of my nests; and though we could distinctly hear the ants walking about, we could not distinguish any other sound.

It is, however, far from improbable that ants may produce sounds entirely beyond our range of hearing. Indeed it is not impossible that insects may possess senses, or rather sensations, of which we can no more form an idea than we should have been able to conceive red or green if the human race had been blind. The human ear is sensitive to vibrations reaching to 38,000 in a second. The sensation of red is produced when 470 millions of millions of vibrations enter the eye in a similar time; but between these two numbers vibrations produce on us only the sensation of heat; we have no special organs of sense adapted to them. But there is no reason in the nature of things why this should be the case with other animals; and the problematical organs possessed by many of the lower forms favour the suggestion. If any apparatus could be devised by which the number of vibrations produced by any given cause could be lowered so as to be brought within the range of our ears, it is probable that the result would be most interesting.

Observations on the Kindness of Ants.

In my previous paper I have given various cases which seem to show that ants are not so uniformly humane as the descriptions of previous writers would seem to imply. Some of those who have done me the honour of noticing my papers have assumed that I disputed altogether the kindly feelings which have been attributed to ants. I should, however, be very sorry to treat my favourites so unfairly. So far as I can observe, ants of the same nest never quarrel. I have never seen the slightest evidence of ill-temper in any of my nests: all is harmony. Nor are instances of active assistance at all rare. Again, indeed I have myself given various cases showing care and tenderness on their part.

In one of my nests of *Formica fusca* was a poor ant which had come into the world without antennæ. Never having previously met with such a case, I watched her with great interest; but she never appeared to leave the nest. At length one day I found her wandering about in an aimless sort of manner, and apparently

not knowing her way at all. After a while she fell in with some specimens of *Lasius flavus*, who directly attacked her. I at once set myself to separate them; but whether owing to the wounds she had received from her enemies, or my rough, though well-meant handling, or both, she was evidently much wounded, and lay helplessly on the ground. After some time another *Formica fusca* from her nest came by. She examined the poor sufferer carefully, then picked her up tenderly and carried her away into the nest. It would have been difficult for any one who witnessed this scene to have denied to this ant the possession of humane feelings.

Again, if an ant is fighting with one of another species, her friends rarely come to her assistance. They seem generally (unless a regular battle is taking place) to take no interest in the matter, and do not even stop to look on. Some species, indeed, in such cases never appear to help one another; and even when this is the case, as for instance in the genus *Lasius*, the truth seems to be that several of them attack the same enemy—their object being to destroy the foe, not to save their friend.

Wasps and Bees.

Further Experiments as to their Knowledge of Colour, &c.

The experiments recorded in one of my previous papers (Journ. Linn. Soc. vol. xii. p. 510) tend to indicate that wasps are less guided by colour than bees. I thought, however, that it would be well to make some more experiments on the subject. On the afternoon, therefore, of the 1st September I put a wasp to some honey on a slip of glass placed over red paper, and, continually supplying fresh honey, allowed her to keep on coming till the 5th. I then moved the paper and the honey about 15 inches, putting another drop of honey on another slip of glass, over green paper, in the old place. She returned to the honey on the green paper. I then replaced the honey and red paper as before, and she came back quite straight to it. I then again moved it, and put honey on blue paper in the old place. She returned, however, quite straight to the honey, without taking any apparent notice of the change of colour. Sept. 7th, I moved the honey and paper about a foot, and put a drop of honey on glass over blue paper in between. She went to the honey on the blue paper. I then let her come again to the honey on the red three or four times, and then as before moved the paper about a foot, and put another drop of

honey over it, placing the old honey on yellow paper in between. She came to the honey on the red paper, but after feeding for about half a minute left it, to try that on the yellow.

I may mention that other observations of the same kind gave similar results; but it is perhaps hardly worth while to give more details.

Indeed, while hive-bees were generally contented with any honey I gave them, wasps showed a very different disposition, and, if there were several drops of honey near one another, flew frequently from one to the other, as if to make sure which they liked best.

Conduct towards their Friends.

With reference to the behaviour as regards comrades, I may observe that the results entirely confirmed those previously arrived at. For instance, a wasp observed and fed from the 7th to the 12th Sept. did not bring more than three or four friends during the whole of that time.

Contributions to the Ornithology of New Guinea. By R. Bowdler Sharpe, F.L.S., F.Z.S., &c. Part V.—On recent Collections from the Neighbourhood of Port Moresby, S.E. New Guinea.

[Read March 20, 1879.]

The collection described in the present paper was formed by Mr. Kendal Broadbent, a well-known Australian naturalist, in the vicinity of Port Moresby and in the interior. It is one of the most important that has been made by the English travellers in South-eastern New Guinea; and it will be interesting to compare the species here enumerated with the forthcoming account of Signor D'Albertis's collections from the Fly River. It may be noticed that in this paper a Parrot of the genus *Aprosmictus* is described, which is closely allied to another species from the Fly River, but yet appears to be distinct, offering a parallel case to the two Crowned Pigeons of Southern New Guinea, where we find *Goura Albertisi* inhabiting the Port-Moresby district replaced by *G. Sclateri* on the Fly River. The same mountain-fauna seems to extend from the latter locality along the southern part of New Guinea, at least as far as the mountains in the interior of Port Moresby, if we may judge by the presence of such birds as *Drymœdus Beccarii* and *Cinclosoma ajax*, which occurs in both Signor D'Albertis's and Mr. Broadbent's collections. When these moun-